



A mitigation approach to reduce dolphin-fishery interaction using acoustic deterrent device on trammel nets in the Northern Tyrrhenian Sea (Tuscany, Italy)

Ceciarini, I.^{1,2}, Franchi, E.¹, Capanni, F.¹, Consales, G.¹, Minoia, L.^{1,3}, Ancora, S.¹, D'Agostino, A.⁴, Lucchetti, A.⁵, Li Veli, D.⁵ & Marsili, L.^{1,2,6}

¹ Department of Physical Sciences, Earth and Environment, University of Siena, Via Pier Andrea Mattioli 4, 53100 Siena, Italy; ² La Casa dei Pesci Onlus, Via Montanese 41, Fonteblanda, Talamone, 58015 Grosseto, Italy; ³ Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Italian National Institute for Marine Biology, Ecology and Biotechnology, Genoa Marine Center (GMC), Via De Marini 6, 16149 Genoa, Italy; ⁴ Department of Business and Quantitative Studies, University of Naples Parthenope, Via Generale Parisi 13, 80132 Naples, Italy; ⁵ Institute for Biological Resources and Marine Biotechnologies (IRBIM), National Research Council (CNR), Largo Fiera della Pesca 1, 60125 Ancona, Italy; ⁶ Centro Interuniversitario per la Ricerca sui Cetacei (CIRCE), Department of Physical Sciences, Earth and Environment, University of Siena, Strada Laterina 8, 53100 Siena, Italy;

Dolphin-fishery interaction is a worldwide and long-standing issue affecting both dolphins through bycatches and fishers through catch or gear damages. Some of these interactions seemed to be positive and beneficial [1], however most of them are negative and harmful (Figure 1 and 2) [2]. In the Mediterranean Sea, this conflicting relationship has been documented mainly between small-scale artisanal fishery and common bottlenose dolphins (*Tursiops truncatus*, Montagu 1821) due to its top predator food chain position, opportunistic feeding behaviour, coastal distribution home range, and marked adaptability [3]. To this end, the impact of dolphin interactions with artisanal fishing in the Mediterranean has been investigated through fisher's interviews [4] and examinations of fishing operation. Acoustic Deterrent Device (ADD) is the most widespread measure used in attempts to mitigate interactions between marine mammals and fishing gear [5].



Figure 1 – *Tursiops truncatus* specimen stranded along Tuscan coast (Italy) with evidence of fishery interactions reporting a trammel nets ropes around the neck.



Figure 2 – A. Artisanal Tuscan fisher (Paolo Fanciulli) showed a hole occurred by a dolphin in the trammel net during a trial with a CTRL net (without pinger). B. *Mullus barbatus* damaged by a dolphin bite.

1. To test Interactive Dolphin Deterrents (DiD01) on trammel nets;
2. evaluate differences of species caught by nets with pingers and without pingers;
3. evaluate catch per unit effort per weight (CPUE_w) and (CPUE_n);
4. evaluate the effectiveness of DiD01 in reducing catch and net damages.

In nearshore waters along the southern Tuscan coast (Italy) (Figure 3), innovative acoustic deterrent devices (DiD01, STM Products S.r.l.) were tested on trammel nets (Figure 4).

All data were collected through onboard fisher and observer logbooks at the beginning and at the end of the haul.



Figure 3 – Study area map showing the four harbours and related experimental area representing all trials both CTRL and TEST hauls: **yellow** AREA 1 (Porto Santo Stefano, GR), **green** AREA 2 (Talamone, GR), **blue** AREA 3 (Marina di Grosseto, GR), and **red** AREA 4 (Piombino, LI).

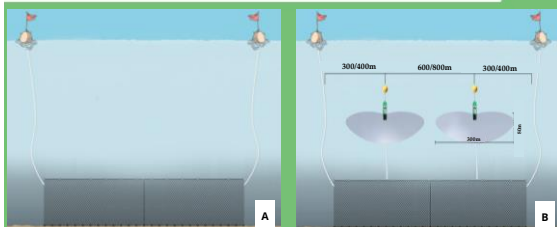


Figure 4 – Experimental design with control net (without pinger) called CTRL (A) and with test net (with pinger) called TEST (B). Also in B it is shown the set-up of the DiD01 (STM Products S.r.l., Verona, Italy) on trammel net with the correct distance between the buoyant signal and each pinger and the emission range of the pinger. Output signals from 5kHz up to 500kHz at 168 dBre 1uPa @ 1 m as raddid high-speed tones FM ranging from 100µs up to seconds.

REFERENCES

1. da Silva Machado, A. M.; Daura-Jorge, F. G.; Herbst, D. F.; Simões-Lopes, P. C.; Ingram, S. N.; de Castilho, P. V.; Peroni, N. Artisanal fishers' perceptions of the ecosystem services derived from a dolphin-human cooperative fishing interaction in southern Brazil. *Ocean Coast. Manage.* 2019, 173, 148-156.
 2. Giacchi, M.L.; Falone, F.; Scarnella, D.; Sardo, G.; Vitale, S. Dolphin-Fisheries Interactions: An Increasing Problem for Medi-terranean Small-Scale Fisheries. *Politics* 2019, 18, 1-8.
 3. Revuelta, O.; Doménech, F.; Fraija-Fernández, N.; Gozáles, P.; Novillo, O.; Penades-Suay, J.; Tomás, J. Interaction between bottlenose dolphins (*Tursiops truncatus*) and artisanal fisheries in the Valencia region (Spanish Mediterranean Sea). *Ocean Coast. Manage.* 2018, 165, 117-125.

From March to October 2021, a total of 139 fishing trials using nets with and without pingers, respectively 97 test and 42 control, were carried in four different areas located in front of the coast of Tuscany. The difference between CTRL and TEST nets was not significant in terms of CPUE_w ($z=0.795$; $p>0.05$) while it was statistically different for CPUE_n ($z=0.016$; $p<0.01$) (Figure 5).

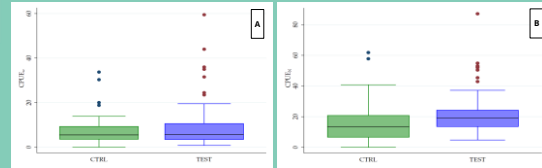


Figure 5 – Boxplots of CPUE_w expressed in $Wc / [(NetLength/1000m) (NetSoakTime/12h)]$ (A) and CPUE_n expressed in $Nc / [(NetLength/1000m) (NetSoakTime/12h)]$ (B) in CTRL and TEST nets in all four areas.

Total species richness in all samples was 59, of which 15 were present only in TEST nets and 2 species only in CTRL.

Sepia officinalis – CTRL resulted the most caught species with 73% and 58%, respectively in CTRL and TEST nets (Figure 6).

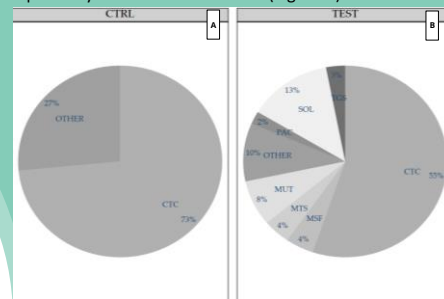


Figure 6 - Percentage of species caught in CTRL (A) and TEST (B) nets reported as FAO Code. "OTHER" includes species that present a number of individuals ≥ 100 .

- The **Sørensen Index**, equal to 0.84 suggested a change in species assemblages between CTRL and TEST nets.
- The **Shannon Equitability Index**, equal to 0.973 and 0.969, respectively in CTRL and TEST nets, indicated a high degree of evenness between species in both catch composition/CTRL and catch composition/ TEST nets; in CTRL this evenness was slightly higher.

Figure 7 shows the occurrence and the frequency of species caught in all four areas.

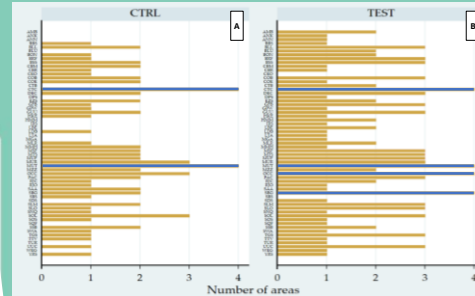


Figure 7 - Graph showing how many times each species is caught in each area for both CTRL (A) and TEST (B) net. The species are reported with FAO Code. In **blue** the species caught in all four areas in both CTRL and TEST nets that are: CTC (*Sepia officinalis*) and MUT (*Mullus barbatus*). Also OCC (*Octopus vulgaris*) and SBG (*Sparus aurata*) were captured in all four areas but only using TEST nets.

Dolphin interactions (including sighting or conflict) were recorded in 18 fishing operations (16 CTRL and 2 TEST). Also the proportion of damages to the catches caused by dolphins was statistically different between CTRL and TEST nets ($z=-5.81$, $p=0.000$).

CONTEXT

CONCLUSIONS

- Dolphin-fishery interactions were reduced significantly using DiD01.
- No reduction in numbers and quantities of catches was documented by using DiD01.

This issue could be overcome with a multidisciplinary approach to:

- monitor population and dolphin behavior for conservation actions;
- evaluate economic losses for fishers to establish the possibility to receive an economic refund [7];
- manufacture new and more advanced pinger;
- raise awareness all fishers about the importance of their collaboration to manage and conserve the *Tursiops truncatus* and the whole marine environment.

RESULTS

MATERIALS & METHODS

Data were first standardized using CPUE (Catch Per Unit Effort) per weight and per number of individuals [6] in order to make comparisons between CTRL and TEST nets in:

- Differences in catches and damages to captures and fishing gear;
- Species similarity (**Sørensen Index**, Sc);
- Evenness of species (**Shannon Equitability Index** (EH));
- Distribution and percentage of species for each area.

4. Li Veli, D.; Petetta, A.; Barone, G.; Ceciarini, I.; Franchi, E.; Marsili, L.; Pietrolungo, G.; Mazzoli, C.; Holzer, D.; D'Argenio, S.; Guccione, S.; Testa, R.L.; Blasi, M.F.; Cinti, M.F.; Liveri Consoli, S.; Rinaldo, I.; Lucchetti, A. Fishers' Perception on the Interaction between Dolphins and Fishing Activities in Italian and Croatian Waters. *Diversity* 2023, 15, 133.
 5. FAO. 2022. The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation. Rome, FAO.
 6. Lucchetti, A.; Bargione, G.; Petetta, A.; Vissapolo, C.; Virgili, M. Reducing Sea Turtle Bycatch in the Mediterranean mixed demersal fisheries. *Front. Mar. Sci.* 2019, 6, 387.
 7. Regional Law, December 5, 2017, n.24. Compensation for damage caused by protected mammals (dolphins). Allocation of the financial resources referred to in paragraph 3 of article 11 of the regional law 9 March 2015, n.5 (Finance Act 2015).